Butler University Botanical Studies

Volume 5 *Butler University Botanical Studies* Article 11

A study of some growth factors affecting asymetical growth in trees

Matthew Harmon
Butler University

Butler University Botanical Studies

(1929-1964)

Edited by

Ray C. Friesner

The *Butler University Botanical Studies* journal was published by the Botany Department of Butler University, Indianapolis, Indiana, from 1929 to 1964. The scientific journal featured original papers primarily on plant ecology, taxonomy, and microbiology. The papers contain valuable historical studies, especially floristic surveys that document Indiana's vegetation in past decades. Authors were Butler faculty, current and former master's degree students and undergraduates, and other Indiana botanists. The journal was started by Stanley Cain, noted conservation biologist, and edited through most of its years of production by Ray C. Friesner, Butler's first botanist and founder of the department in 1919. The journal was distributed to learned societies and libraries through exchange.

During the years of the journal's publication, the Butler University Botany Department had an active program of research and student training. 201 bachelor's degrees and 75 master's degrees in Botany were conferred during this period. Thirty-five of these graduates went on to earn doctorates at other institutions.

The Botany Department attracted many notable faculty members and students. Distinguished faculty, in addition to Cain and Friesner , included John E. Potzger, a forest ecologist and palynologist, Willard Nelson Clute, co-founder of the American Fern Society, Marion T. Hall, former director of the Morton Arboretum, C. Mervin Palmer, Rex Webster, and John Pelton. Some of the former undergraduate and master's students who made active contributions to the fields of botany and ecology include Dwight. W. Billings, Fay Kenoyer Daily, William A. Daily, Rexford Daudenmire, Francis Hueber, Frank McCormick, Scott McCoy, Robert Petty, Potzger, Helene Starcs, and Theodore Sperry. Cain, Daubenmire, Potzger, and Billings served as Presidents of the Ecological Society of America.

Requests for use of materials, especially figures and tables for use in ecology text books, from the *Butler University Botanical Studies* continue to be granted. For more information, visit www.butler.edu/

A STUDY OF SOME FACTORS AFFECTING ASYMMETRICAL GROWTH OF TREES

By MATTHEW H. HARMON

Observations on stumps left by lumbering operations show that in many cases the organic center of the stump is far removed from the geometric center. This led into an investigation of factors causing asymmetrical growth of trees. As there has been but little research on unsymmetrical growth, little light has been thrown upon the subject by a perusal of the literature. Friesner (5) states that unsymmetrical growth is due to a combination of factors, some internal and some external, of which location of spreading roots, itself determined partly by internal and partly by external factors, variation in slope and other soil relations, and competition with other trees are the most likely. Glock (6) states that fluctuations in width of an individual ring on different radii of the same year ring is probably influenced by root activity. Areas of wide growth have a greater tendency to cluster about certain radii near the base of the stem than they do farther up the trunk of the tree. Cooper (3) states that in layering branches of Sitka spruce and two western hemlocks, asymmetrical growth is due to production of adventitious roots resulting in increase in the water supply. This stimulates wood growth on the side receiving the greatest supply of water, thus contributing to asymmetrical growth. Brown (2) says that uneven growth in width of the rings is affected directly by the amount of conducting tissue. The amount of conducting tissue in the trunk is proportionate to the conducting tissue in the roots. Thus, if one root has a large supply of conducting tissue there will also be a large amount of conducting tissue directly above that root in the trunk. Auchter (1) has shown that mineral salts absorbed by a root in one vertical zone of a tree are primarily used in that same zone and not laterally distributed to any great extent. Lodewick (7) working on the longleaf pine of Florida found that there is little relation between unequal crown and amount of growth in radical directions in the vertical zones beneath the crown variations.

METHODS AND MATERIALS

Cores were obtained by use of a Swedish increment borer from standing trees of *Quercus borealis. Q. alba, Q. shumardii, Q. mon-*

tana, Q. velutina, Fraxinus americana, Carya glabra, C. ovata, Acer saccharum, Platanus occidentalis, Liriodendron tulipifera and *Populus grandidentata*. The cores were taken between 75-115 cm above the surface of the soil and upon removal from the borer they were glued into rabbited pine blocks, numbered and taken to the laboratory for measurement of annual growth. Around the trees from which cores were taken, all other trees within a radius of 35 feet from the sample tree were measured and carefully located by means of a tape measure and compass on polar graph paper. The earth was dug away from the base of each tree so as to expose main spreading roots and their location was also plotted on polar graph paper.

The trees selected for boring were chosen from predetermined environmental groups which appeared to have one outstanding factor unequally affecting the growth of the tree. The factors were as follows: 1) Trees growing close enough together that competition must be one of the most important factors in their growth and must affect the tree unequally on different vertical zones. 2) Relation between tree and position in the soil, i. e. trees directly on ravine bank or trees on gentle slopes. 3) Trees located so as to be affected by moisture, i. e. trees located on the bank of permanent streams, containing water the year around, and trees located on the bank of streams that contain water only during the wet season of the year. 4) Trees showing well developed root systems.

Cores were taken so as to show the following factors which may affect growth: 1) along radii which were vertically above the main spreading roots and along other radii which were between these roots. 2) Along radii which divided the up-hill and down-hill side of trees. 3) Along radii that if extended would intercept trees near enough to appear to cause root competition. All cores were of sufficient length to pass through the geometric center of the trees. All holes left by the borings were plugged with grafting wax.

Measurements of cores were made under low power of a binocular microscope with a ruler divided into 0.5 mm. Thus measurement could be made accurately to the nearest 0.25 mm. Cores before being measured were trimmed with razor blades so as to present a flat surface, thus making the year rings stand out much more clearly.

EFFECT OF ROOTS ON ASYMMETRICAL GROWTH

In the present study cores were taken in zones directly above the main spreading roots and between such roots. From table I it will be seen that the average growth along radii above roots is greater than that above spaces between roots in only 9 out of the 16 trees used. The longest radius in each individual tree occurred in a zone vertically above a spreading root in 12 of the 16 trees, the other 4 having their longest radius in a vertical zone above the space between roots. The shortest radius of each individual tree occurred in a zone above the space between roots in 11 of the 16 trees, the other 5 having their shortest radius above roots.

These results appear to be in conflict to a considerable degree with those of Friesner (5). Two important differences between the present work and that of Friesner make it difficult to ascertain precisely how much conflict there is in results. (1) The present paper deals with 8 species of trees only two specimens of which were *Q. velutina*, whereas the former paper was based entirely on the latter species. (2) Present results are from borings 15-115 cm above the soil while the former paper dealt with sections cut from the tops of stumps 30-40 cm from the soil. It is to be expected that the effect of root location upon growth will be greater the nearer the material studied is to the roots themselves. Since the cores used in the present study are approximately 3 times as far from the roots the relationship should be expected to be less distinct. It should also be borne in mind that radii measured from cut sections can follow medullary rays and hence be true "organic radii" whereas those measured from borings are "geometrical radii" but not necessarily "organic radii."

RELATION OF SLOPE TO UNSYMMETRICAL GROWTH

It has been shown by Douglass (4) that slope affects eccentric growth in Western pine when slope is such that it makes water available earlier on one side of the tree than the other. Table II shows the relation of slope to eccentric growth. Out of 11 trees growing on gentle slopes, 7 showed greater growth on the downhill side. Of these 7 trees, 6 had the same number of spreading roots on both the uphill and downhill slope. In tree no. 35 growth occurred on the side of the tree having the most roots. This was the downhill side of the tree. In 4 trees showing greatest growth on uphill side of tree, two of them (11 and 14) did have more roots on the uphill side of the tree than on the downhill side. Of the other two trees, one (no. 24) had more roots on the downhill side of the tree but showed greater growth on the uphill side. Tree no. 36, however, had the same number of roots on both sides of it, yet this tree grew most on the uphill side. However, when differences in growth on both slopes is averaged, more growth appears on the uphill slope. This difference is so little, only 0.23 mm per radius, that no importance may be attached to it. The conclusion may be drawn that slope variations give no dependable relationship to eccentric growth although there is some evidence to show that on gentle slopes the downhill side of the tree will be favored at the expense of the uphill side.

Ten trees on the edge of a ravine bank were selected for study. The data are in table II. Of these 10 trees, one tree (no. 6) apparently was not affected by its location. It grew the same amount on both the bank and the brink side of the tree. There was an equal number of roots present on each side. However, in 5 other trees (nos. 10, 13, 31, 5 and 7) more growth occurred on the bank side of the trees. The 5 trees each had, however, greater number of roots on the brink side than on the bank side. This may only be apparent and not real, due to better chance to observe roots on the brink side. In 4 remaining trees (nos. 34, 26, 33 and 32) growth occurred more on the brink side of the tree than on the bank side. Tree no. 32 had the same number of spreading roots on both sides of the tree. Tree no. 26 had more roots on the bank side but grew more on the brink side. In trees no. 34 and 33 the spreading roots were too deeply located to be plotted and observed. However, these two trees also showed greatest growth on the brink side of the tree. From this study of trees located on ravine bank, the conclusion can be drawn that slope variations do not give a dependable relationship to eccentric growth.

EFFECT OF COMPETITION ON ECCENTRIC GROWTH

Four trees growing in such a position that competition must have affected them were chosen for this study. All were *Liriodendron tulipifera*. Trees no. 19 and 20 were but six feet apart, each was 17.5 inches DBH. and was located on a gentle slope. No. 28 and 29 were four feet apart and were 13 and 11 inches DBH. respectively. They were located in a forest dominated by *Fagus grandifolia* ranging from 18 to 30 inches DBH. which were fairly evenly spaced 25-75 feet apart. Table III shows the competition data. The competition side of tree no. 19 was uphill. Average growth of radii no. 1, 2, and 3 is 162.9 mm, while the non-competition side showed an average growth of 181.66 mm. This was 29.3% more growth on the side without competition. Tree No. 20 had an average growth of 149.5 mm on the competition side and 156 mm on the side without competition. This was 4.59% greater growth on the side without competition. Tree no. 28 had an average growth of 168 mm on the side with competition, the non-competition side having an average of 232.66 mm which is 38.49% greater growth on the non-competition side of the tree. Tree no. 29 had an average growth of 237.33 mm on the competition side and an average of 147 mm on the non-competition side. This is 91% greater growth on the competition side. Thus in three of the four trees (no. 19, 18 and 28) the side of the tree having competition showed 4.59-38.40% less growth than the non-competition side (table III). Tree no. 29 must have been influenced much more greatly by some factor other than competition since this tree grew more every year on the competition side of the tree than on the non-competition side. In these trees of *L. tulipifera* the side away from competition, if not influenced by some other controlling factor, grew more than the side with competition thus leading to unsymmetrical growth. The factor that controlled growth in tree no. 29 is believed to be that of water content of the soil. This study shows that competition as a factor may influence unsymmetrical growth but that it is easily overshadowed by other controlling factors.

Table IV presents data showing the effect of competition at different age periods of these trees (*L. tulipifera*). It will be observed that competition was effective for a larger number of "radius-years" during the second and third 10-year periods in tree no. 19 whose borings comprised 58 years of growth per radius; during the third and fourth 10-year periods in tree no. 20 whose borings showed 52 years of growth per radius; and during the first 10-year period in tree no. 28 whose borings showed 30 years of growth.

EFFECT OF WET-WEATHER STREAMS

Table V shows data of trees growing on banks of streams that were carrying water only during the rainy season of the year. In three out of four trees studied, more growth occurred on the bank side of the tree, i. e. the side where roots were farther from the stream, but tree no. 2 grew more on the stream side. Similar behavior occurred in tree no. 1 which also grew more on the stream side. Tree no. 1 however grew on the bank of a stream containing water the year around. On the basis of these data it appears that trees growing on the banks of streams that contain water only in the rainy season grow more on the bank side than on the stream side of the tree. This is most likely due to the presence of fewer roots in soil along the stream side, together with a more uniform supply of soil water on the bank side. Also in the rainy season of the year there would be a surplus of water which would saturate the ground, making for bad aeration and leaching minerals out of the ground thus causing growth to be retarded on the stream side. Due to this surplus water, roots on the stream side are apt to become shallow as the most favorable growing season is in spring when this surplus water occurs. The roots would tend to become water logged thus again retarding growth. This shallowing of roots in spring would be reflected in the summer growth as it would not permit roots to he deep enough in the ground to obtain a plentiful supply of water and salts during drier seasons. This would result in decreased supply of water and salts on the stream side of the tree with a resulting decrease in growth on that side. Roots on the stream side of trees would be more likely to be damaged by washing of water in wet-weather streams and their tissues would be torn by the movement of rocks and debris of the stream. This would not be so apt to occur in permanent streams since there is an even current rather than a swift destroying current of the wet-weather streams.

DISCUSSION

Of many factors that show any demonstrable relation to unsymmetrical growth, position of main spreading roots, slopes and competition are the 3 most evident. In this study it was found that in most cases trees which had main spreading roots on the downhill side of the tree grew most on this side. From this the conclusion may be drawn that slope plus root location combined play a most important role in eccentric growth. Slope alone, if only gentle, plays but a small role in unsymmetrical growth. Greater growth tends to be on the downhill side of the tree on gentle slopes. However, if the slope is steep, such as on the banks of a ravine, growth appears to be greater on the uphill side. It is possible that the reason growth is greater on the downhill side of the tree on gentle slopes is because of leaching of mineral salts downward on the slope thus making for a greater concentration toward the bottom of the slope. The water table would be higher, too, at the foot of the slope than at the top. Thus the trees would tend to send more roots downhill because of greater available water supply and mineral salt concentration.

This would tend to permit greater passage of salts and water on the downhill side of the trees thereby permitting more growth on this side of the trees.

On the other hand, trees growing on a steep slope, ravine brink, or bank of temporary stream are more likely to be able to have a more adequate root supply on the uphill side (due to erosion) than on the downhill side. This should be reflected in greater growth on the uphill side. This is borne out by results shown in table II.

It was found that trees growing off streams that contain water only in the rainy season show the most growth on the side away from the stream. These trees may have the same number of spreading roots on each side and still this holds true.

Competition was another factor studied in this experiment. Weaver and Clements (8) state that competition between species of the same kind is strongest. In trees studied it was found that growth was less on the competition than on the non-competition side. This was probably due to the fact that roots on the competition side of two trees were constantly competing with each other for space in the soil, for nutrients and, probably most important of all, for water. However if one of the competing trees is favored by some additional factor more than the other as in the case of trees no. 28 and 29, then the competition factor may be offset. Judging from the site, tree no. 29 received more water on its competition side than it did on its non-competition side. If this is true, it would account for the fact that of four trees studied this was the only one showing more growth on the competition side than on the non-competition side. Another factor of competition is light. In this experiment two of the competing trees were but 4 feet apart and the other two were but 6 feet apart. This would be likely to affect the leaf and its activity by making fewer branches and fewer leaves and, hence, less food on the competition side.

Asymmetrical growth is due to a combination of many factors of which no one can be said to be directly responsible. However, of these factors some are more important than others. The factors that show the greatest response in unsymmetrical growth are probably root position, slope and competition. Of these three factors, root position combined with slope is the most important.

SUMMARY

1. Cores were obtained from standing trees showing differences

in the following factors: 1) root position, 2) competition, 3) slope, 4) banks of streams containing water only in the rainy season and 5) ravine banks.

2. Average growth per radius is greater in vertical zones above roots in only 50% of the trees studied, but total growth above roots when all trees are considered is greater than total growth between roots.

3. Gentle slope as a part of a complex of factors usually favors the downhill side of the tree in unsymmetrical growth.

4. Very steep slopes such as a ravine brink affects unsymmetrical growth in that growth is less on the brink side of the tree than on the bank or uphill side of the tree.

5. Competition when not offset by other factors exerts a demonstrable influence upon asymmetrical growth in that growth on the competition side is less than on the non-competition side of trees. This is correlated with greater root supply on the non-competition side of trees.

6. Trees standing on the banks of temporary streams usually show greater growth on the side away from the stream.

LITERATURE CITED

1. Auchter, E. C. Is there normally a cross-transfer of food, water and mineral salts in woody plants? Maryland Agr. Exp. Sta. Bul. 257. 1923.
2. Broun, H. P. Growth studies in forest trees. Bot. Gaz. 59:197-241. 1915.
3. Cooper, Wm. S. Layering habit in Sitka spruce and two western hemlocks. Bot. Gaz. 91:441-550. 1931.
4. Douglass, A. E. Climatic cycles and tree growth: a study of the annual rings of trees in relation to climatic and solar activity. Carnegie Inst. Wash. Pub. 289. 1936.
5. Friesner, R. C. A study of asymmetrical growth from stump sections of *Quercus velutina*. Butler Univ. Bot. Stud. 4:197-202. 1940.
6. Glock, W. S. Principles and methods of tree ring analysis. Carnegie Inst. Wash. Pub. 486. 1937.
7. Lodewick, J. E. Effect of eertain climatic factors on diameter growth of longleaf pine of Western Florida. Jour. Agr. Res. 41:349-363. 1930.
8. Weaver, J. E. and F. C. Clements. Plant Ecology. McGraw-Hill Book Co., New York. 1935.

TABLE I

Relation between growth along radii which center on main spreading roots and those which come between such roots. Figures are averages of all radii of each type for each tree.

Tree		Radii on Roots Number of Radii	Radii on Roots Growth	Radii off Roots Number of Radii	Radii off Roots Growth
Q. velutina	8	4	264.21 mm	3	276.58 mm
Q. velutina	32	3	188.66	3	226.58
Liriodendron	11	4	276.43	4	287.31
Liriodendron	12	4	152.27	4	162.06
Liriodendron	13	3	156.62	3	148.12
Liriodendron	21	3	154.09	3	148.19
Acer saccharum	15	4	77.21	4	80.65
Acer saccharum	24	3	93.75	3	90.50
Carya ovata	16	4	171.31	4	154.12
Carya ovata	22	4	99.15	4	102.72
Q. alba	18	4	156.40	4	164.59
P. grandidentata	23	4	116.53	4	121.55
P. grandidentata	26	4	103.90	4	102.31
P. grandidentata	27	4	165.15	4	149.78
Q. borealis	38	4	90.66	4	88.75
Platanus occidentalis	35	5	218.52	3	168 29
Total			2484.76		2471.10

TABLE II

Effect of slope on unsymmetrical growth. Figures are average growth per radius.

Tree		Uphill Number of spreading roots	Uphill Average Growth	Downhill Number of spreading roots	Downhill Average Growth
		A. Gentle Slope			
L. tulipifera	14	2	133.33 mm	1	109.00 mm
Acer saccharum	15	2	74.28	2	83.84
Carya ovata	16	2	163.46	2	164.25
Q. alba	18	2	148.75	2	167.62
L. tulipifera	21	2	155.83	1	146.58
Carya ovata	22	1	95.12	1	107.12
P. grandidentata	23	1	118.58	1	125.62
Acer saccharum	24	1	103.39	2	97.50
Q. shumardii	35	2	165.86	3	200.45
Q. borealis	36	2	189.42	2	158.00
Q. borealis	38	2	86.90	2	91.33

TABLE II—(Continued)

Tree		Uphill: Number of spreading roots	Uphill: Average Growth	Downhill: Number of spreading roots	Downhill: Average Growth
		B. Ravine Brink			
Q. montana	5	3	192.65	4	97.50
Q. borealis	6	2	85.00	2	85.00
Q. velutina	7	3	280.00	5	170.80
L. tulipifera	10	1	110.50	2	53.80
L. tulipifera	13	2	175.00	3	142.65
P. grandidentata	26	3	102.70	1	109.00
P. grandidentata	31	0	91.50	0	89.00
Q. velutina	32	2	101.80	2	105.50
Q. montana	33	0	43.80	0	61.80
Carya glabra	34	0	82.00	3	89.15

TABLE III

Relation between growth along radii with and without competition with other trees.

Tree No.	Radius	Competition Description	Growth	Radius	Non competition Description	Growth
19	1	17.5" Liriodendron, 6' away	163.00 mm	4	opposite radius 1	185.25 mm
	2	same	146.60	5	opposite radius 2	180.87
	3	same	179.00	6	opposite radius 3	178.87
		Average	162.90		Average	181.66
20	4	18" Liriodendron, 6' away	128.50	1	opposite radius 4	136.00
	5	same	163.50	2	opposite radius 6	160.50
	6	same	156.50	3	opposite radius 5	171.50
		Average	149.50		Average	156.00
28	1	11" Liriodendron, 4' away	151.00	4	opposite radius 1	228.00
	2	same	152.00	5	opposite radius 2	294.00
	3	same	176.00	6	opposite radius 3	173.00
		Average	168 00		Average	232.66
29	4	13" Liriodendron, 4' away	259.00	1	opposite radius 4	115.00

TABLE III—(Continued)

Tree No.	Radius	Competition Description	Growth	Radius	Non-competition Description	Growth
	5	same	269.00	2	opposite radius 6	139.00
	6	same	214.00	3	opposite radius 5	187.00
		Average	237.33		Average	147.00

TABLE IV

Effect of competition on each ten years of life of tree. Percentages are for the average number of years that growth was greater on the non-competition side of the tree than on the competition side.

Tree No.	First 10-Yr. Period	Second 10-Yr. Period	Third 10-Yr. Period	Fourth 10-Yr. Period	Fifth 10-Yr. Period
19	60%	90%	80%	60%	50%*
20	30	50	80	70	100 **
28	90	60	60		
29	0	0	0 ***		

* Only 8 years of growth.

** Only 2 years of growth.

*** Competition side showed 100% greater growth every year than non-competition side of tree.

TABLE V

Effect of position of banks of streams on eccentric growth. Four of the trees were located on edge of stream carrying water only in rainy season. Growth figures are averages per radius.

Tree No.		Bank Side Radii Counted	Bank Side Growth	Stream Side Radii Counted	Stream Side Growth
Q. alba	2	3	120 83 mm	3	125.33 mm
Platanus	25	3	114.50	3	111.33
Platanus	30	3	107.33	3	105.33
Liriodendron	39	3	191.50	3	122.16
Fraxinus	1*	3	110.16	3	111.33

* On bank of permanent stream.